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THE MEDICAL RESULTS OF HUMAN EXPOSURES TO RADIO FREQUENCY RADIATION

USAF Occupational and Environmental Health Laboratory
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This report was prepared as a paper for presentation at the AGARD Aerospace Medical Lecture Series, Number 138 in Portugal, France, and Italy in April of 1985. It is a summary of the USAF Air Force experience in the realm of accidental overexposures to RFR. It contains a brief history of the Air Force RFR protection program, some examples of accidents that have occurred, and an overview of the medical implications of those overexposures as we understand them today.

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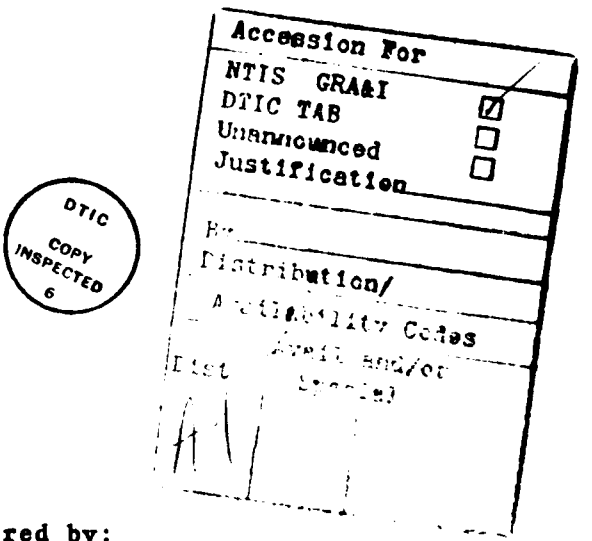
The Medical Results of Human Exposures To Radio Frequency Radiation



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I. SUMMARY

The United States Air Force has conducted a clearly defined and effective radio frequency radiation (RFR) protection program since 1970. As an important part of the program, since 1972 the Air Force Medical Service has investigated RFR exposure incidents involving more than 330 individuals; of which 58 were determined to have been actually overexposed with another 17 found to have been inconclusive. Medical evaluations of the exposees have been extensive and the findings almost universally unremarkable. This report presents a short history of the program's evolution, some examples of exposure incidents and some general impressions of the clinical evaluations of the confirmed exposees.

II. INTRODUCTION AND BACKGROUND

The U.S. Air Force has always placed great emphasis on safe working conditions for its personnel. Radiation protection programs for the work force have enjoyed a high priority and an excellent reputation for effectiveness over the years.

Prior to 1970, radio frequency radiation (RFR) protection programs within the Air Force community were largely managed at base-level. In mid-1970, the USAF Radiological Health Laboratory, a predecessor of the USAF Occupational and Environmental Health Laboratory (USAF OEHL), was tasked by the Air Force Surgeon General to develop an RF radiation protection program for implementation Air Force-wide.

During the period from 1965-1975 RF radiation protection efforts in the U.S. Air Force were governed by a medical directive, Air Force Manual (AFM) 161-7, Control of Hazards to Health from Microwave Radiation. The Permissible Exposure Limit (PEL) for occupational exposure to microwaves (RFR) was clearly established at 10 mW/cm^2 averaged over any 6 minute period. There was no specific provision for time-averaged exposures nor for consideration of scanning factors. The guidelines concerning the management of real or suspected overexposures to RF energy were ambiguous and contained no guidance or policies regarding overall management of the program or for making measurements when required.

Air Force Regulation (AFR) 100-6, Electromagnetic Interference and Radiation Hazards, contained then, as it does today, some delineation of responsibilities for field measurements. However, no provision existed for the nonmedical units with measurement capability/responsibility to effectively interface with the medical personnel who were not only responsible for base-level programs, but also for developing and setting PELs.

As a first order of business, personnel of the USAF Radiological Health Laboratory (USAFRHL) undertook to establish and solidify liaison with those nonmedical units who were doing field measurements. In late 1971 the principle organization so involved was abolished and the mission reestablished under the Electromagnetic Compatibility and Measurements (EMCβM) function of

Headquarters Air Force Communications Service (AFCS). AFCS was later designated a Major Air Command and renamed the Air Force Communications Command (AFCC). This last action had no effect on the measurement mission, however.

About 1970, intense interest, Congressional and otherwise, was generated by allegations that radar operators had been exposed to hazardous levels of RFR which had caused cataracts while on the job in certain aircraft. The Air Force Medical Service found itself in need of measured data to support its medical evaluations to the contrary. As a result, in late 1970, under specific direction of the Air Force Chief of Staff through the Surgeon General, USAFRHL and AFCS conducted the first of a series of studies to determine if the allegations of RFR (microwave) cataractogenisis in fact had any basis. That first study lacked sophistication, but the investigators were unable to distinguish any difference in the eyes of career RF workers when compared to a matched group of non-RF workers.[1]

Shortly after that study was completed, the first of several revisions to AFR 100-6 was published, that more clearly defined the responsibilities for field measurements and how the data were to be disseminated to the medical community. It also, for the first time, assigned some field measurement responsibilities to the Air Force Medical Service. Also, at that time, work was begun to revise AFM 161-7 and reestablish it as a regulation with directive authority.

In 1972, interest was revived in microwave cataractogenisis by proposed Congressional Hearings on the matter. The Air Force medical community seized on that opportunity to mount a more comprehensive study of the matter than was the 1970 effort. There had been two additional Air Force studies, similar in sophistication to the first, that were conducted with U.S. Army participation in 1971.[2],[3] The 1972 study again included AFCS to provide measurements and involved nearly 1000 subjects. About one-half that number were in the study group and had worked in RFR occupations from 2 to more than 45 years. The other half formed a control group and were carefully selected for having had no occupational exposure to radiation and were just as carefully matched for age. The results of that so called "Five-Base Study" demonstrated that microwave cataractogenisis was a nonentity within the Air Force work force.[4],[5] Primarily as the result of that study, microwave radiation was largely dismissed as a possible/probable cause of cataract activity among Air Force workers who are/were occupationally exposed at levels within the PEL.[3] That fact remains essentially true today.

In the fall of 1975, AFM 161-7 was rescinded and replaced by AFR 161-42, Radio Frequency Radiation Health Hazards Control, which provided for a more extensive RFR control program. Just before the appearance of the new regulation, decisions were made at the highest levels of the Air Force Medical Service that the program would be totally managed by Bioenvironmental Engineers at base-level. Consultant expertise would be developed at USAFRHL and efforts undertaken to acquire and maintain state-of-the-art instrumentation for loan to the field as needed.

AFR 161-42, also contained guidance and procedures for the management of overexposures to RFR. As a practical matter these procedures had been

developed and loosely followed since early in 1972 when the first alleged overexposure was investigated and reconstructed. From that beginning, were developed the policies and procedures that were incorporated in AFR 161-42 in Nov 75.

As is often, if not usually, the case with fledgling efforts, the newly directed program was still somewhat hampered by inadequate authority to accomplish what needed to be done, by clear delineation of organizational responsibilities, and by deficiencies in awareness training of RFR workers. In addition, the Occupational Safety and Health Administration (OSHA), an arm of the U.S. Department of Labor, promulgated RFR Standards that were at slight variance with those of the Air Force. Those events led to still another revision of AFR 161-42 which was rescinded in 1978 when Air Force Occupational Safety and Health Standard (AFOSH Std) 161-9 appeared in October of 1978. That document served very well to guide the Air Force's program for several years but still had very basic inadequacies insofar as the management of overexposures was concerned. This was particularly true as regards where and by whom medical evaluations of individuals who were documented to have been overexposed would be accomplished. A current revision of AFOSH Std 161-9 was published in the fall of 1984 and essentially resolves virtually all of the program management difficulties that have been troublesome since 1970. It is the current guideline and authority by which the program is now managed and conducted. It also incorporates frequency dependent PELs from 10 KHz to 300 GHz. Under the authority of this Standard, personnel are trained and assigned a specific responsibility to maintain a high degree of safety in all RFR operations.

III. RFR ACCIDENT INVESTIGATIONS

Since the spring of 1972 the Air Force Medical Service has investigated RFR exposure incidents involving more than 330 individuals. Of that number 58 have been confirmed as overexposures and another 17 yielded inconclusive results, but were treated as overexposures as a matter of medical and legal prudence.

AFOSH Std 161-9 not only sets down the PELs for Air Force personnel, but it also specifically details how to prevent unnecessary or harmful exposures to personnel. In addition, it provides specific guidance as to what actions are required when an accident happens and/or when a real or suspected overexposure has occurred.

As previously noted, the RFR program in the Air Force is managed at base-level by the Base Bioenvironmental Engineer (BEE). These engineers have received at least some training in the management of RFR problems, and many have had extensive experience in the field.

Until 1979 very little RFR measuring equipment was available in the field and it was necessary for USAFRHL, and later USAF OEHL to either loan instrumentation to the bases which needed it, or to perform the surveys/evaluations themselves. That situation has markedly improved, so that today, over 40% of all Air Force bases have on hand adequate instrumentation for making field measurements of at least 95% of the emitters on any given base.

Since 1972, it has been Air Force policy that every suspected or alleged exposure to RFR in excess of the PEL be thoroughly investigated in order to: (1) positively determine whether or not an overexposure did occur; (2) if an overexposure did occur, to definitively determine both the power density level encountered and the length (time) of the exposure; and (3) recommend and coordinate appropriate medical evaluations should they be indicated.

The Standard requires that whenever a suspected overexposure occurs, or whenever an individual alleges one has occurred, the individual(s) involved must promptly report the matter to their supervisor. It is then incumbent upon the supervisor to insure that the individual(s) report promptly to an appropriate medical facility, usually the base hospital. The Standard also requires that Directors of Base Medical Services (DBMS), generally the hospital commander, insure that their physician staff know and understand the principles of RFR injury and the appropriate tests and treatments that may be needed. If the RFR accident victims are in no obvious danger, the symptoms of any possible post-incident injury or illness requiring diagnostic evaluations will generally determine if hospital admission is necessary.

Air Force workers who are potentially exposed to RFR while on the job are also subject to the same illnesses and injuries that are typical of nearly all industrial workers. It is axiomatic then that lifesaving support measures appropriate to the presenting clinical symptoms must be given the highest priority. Most, if not all individuals overexposed to RFR at intensities less than those which are known to cause frank burns, will in all likelihood, manifest little or no immediate evidence of either physical distress or altered physiological function. The psychological/emotional reaction to the exposure, however, may be quite severe and may even require hospitalization for a short time for proper management and relief of the anxiety state commonly seen. The primary concern during the initial visit to the medical facility post-accident is to try and quantitate the exposure history in relation to any manifest symptoms and to document in detail certain medical baselines against which changes, should they occur, can later be measured. It is, therefore, imperative that a complete and comprehensive case record be established that will facilitate future decisions regarding the need for follow-up medical examinations and evaluation of the findings.

While the Standard specifically charges the DBMS with responsibility for initiating and conducting an investigation of all RFR accidents, as a practical matter, the Base BEE almost always acts in behalf of the commander in insuring that the proper actions are taken and that the documentation is complete. The investigating officer, who is also usually the Base BEE, must promptly gather the following background information concerning the accident/incident: (1) name, rank, and service number of all personnel involved; (2) RFR emitter nomenclature and operating parameters at the time of the incident to include frequency, peak power, pulse width (PW), pulse repetition frequency rate (PRF), antenna characteristics, scan or rotation rate, beam configuration, etc.; (3) a description of what happened including date, time, place, duration and location and position of affected personnel in relation to the emitter in question. It is often possible to draw very significant but tentative conclusions at this point regarding the possibility/probability of an overexposure having occurred.

As soon as the salient facts surrounding the accident are known, the Standard requires that prompt notification of the matter be made to the next higher headquarters; e.g., Major Air Command (MAJCOM), usually the Command BEE. The Radiation Services Division of the USAF OEHL must also be notified. The USAF OEHL can and does provide expert guidance and assistance to the Base BEE in the conduct of the investigation, reconstruction and documentation of the incident. It becomes incumbent on the Base BEE at this point to decide whether or not he/she will do the investigation/reconstruction/documentation themselves or ask USAF OEHL to assume that responsibility. There is a relatively good case to be made for either approach, but generally it is felt that USAF OEHL is better able to assume the responsibility. There is, however, no requirement that it be done one way over the other.

The important point to be made is that it is absolutely imperative that the investigation be done just as soon as possible after the incident, primarily because the recall of those involved tends to become seriously flawed as time passes.

The incident must be meticulously reconstructed using the same emitter, operating at identical parameters, and at the direction of the personnel involved. The Standard is quite specific regarding these matters, even to including a discussion of radiation safety considerations for investigating personnel. Once the reconstruction has been completed, the data must be evaluated and a definitive determination made as to whether or not an overexposure did or did not occur. There are a great number of considerations that may come into play in making that determination, but those lie outside the scope of this report.

If it is conclusively determined that no overexposure occurred all medical activity connected with the incident is halted and detailed documentation to support that conclusion prepared. Copies are then distributed, including one permanently filed in the individual's medical record. Higher headquarters and safety offices are, of course, also included.

Occasionally, there are exposure incidents where the investigation is inconclusive as regards overexposure or no overexposure. This can occur where there are conflicting witness observations or perhaps when a really accurate reconstruction cannot be accomplished. There have been 14 such incidents in the Air Force since 1972 that involved 17 individuals. In such cases it is considered to be medically and legally prudent to treat them as though they were overexposures.

When it is conclusively determined that an overexposure did in fact occur or when the investigation is definitively inconclusive, there are a number of actions that are required by the Standard:

1. An accurate as possible quantification of the exposure

2. A determination as to what part of the body was primarily exposed, or was it a whole body exposure

3. A detailed review of any clinical symptoms manifested by the victims

4. Prompt consultation with Board Certified Occupational Medicine Physician(s) at USAF OEHL to determine what, if any, further medical evaluations are needed, and if so, where they will be obtained

The Air Force Standard also specifies in detail, what kinds of medical consultations/evaluations should be considered necessary under what kinds of overexposure situations. It addition, it outlines which medical offices/agencies are responsible for the professional and administrative management of these individuals. As a last point, all individuals who have been determined to have been overexposed to RFR, or those who are assumed to have been, are tracked throughout their Air Force career. They are periodically scheduled for medical reevaluation as appropriate to the magnitude of the exposure, etc. USAF OEHL has responsibility for this tracking procedure.

IV. THE U.S. AIR FORCE RFR ACCIDENT EXPERIENCE

In order to provide the reader with an actual frame of reference as to what kinds of alleged and confirmed RFR overexposures the Air Force has experienced, the following examples are presented:

Example 1: In June of 1974 while deployed in the field, a mobile communications technician was accidently exposed to RFR while attempting to connect a flexible wave guide to the output port of a TRC-97A tropospheric scatter unit.

The cause of this accident was never really determined, but the transmitter was operating in the CW mode at about 1 Kilowatt in the C-band (see Table 1). The technician's head was approximately 14 inches (35.5 cm) from the output port and he essentially looked directly into it. Within seconds the individual experienced intense subjective heating and within minutes was suffering from an acute anxiety reaction that required hospitalization and sedation. Within 30 hours, all symptoms had subsided and the individual returned to duty.

The reconstruction/investigation was conducted by USAFRHL and an exposure level of approximately 720 mW/cm^2 for about 30 seconds (21,600 $mW-s/cm^2$) was confirmed to have occurred. This exposure exceeded the existing PEL by a factor of 6. The victim was referred to the USAF School of Aerospace Medicine (USAFSAM) for complete medical evaluation. Over the next several years, this individual was reevaluated at USAFSAM on many occasions. Since the exposure was almost exclusively to the head, much attention has been directed toward the eyes. To this day the individual is well and the eyes unremarkable.

Table 1

Letter Designation of the Radar Bands[7]

Band	Frequency Range (MHz)
P	220 - 390
L	390 - 1550
S	1550 - 5200*
C	3900 - 6200*
J	6000 - 9000*
X	9000 - 10900
Ku	10900 - 22000
Ka	22000 - 36000
Q	36000 - 46000
V	46000 - 56000

*Note Overlaps

Example 2: In September of 1975 an autotrack (MSQ-46/M-33) radar technician was making precision calibration adjustments on the antenna, when the transmitter was inadvertently energized by another technician who was not aware of the calibration activities.

At the moment of exposure, the radar was operating in J-band at 350 KW peak power and a DF of 0.00025. The exposure was primarily to the scrotal area and the individual experienced only very mild subjective heating and was essentially unware of what had transpired until he had climbed down from the antenna and returned to the operations van.

The reconstruction/investigation was again conducted by USAFRHL at the request of the Base BEE. An exposure level of about 850 mW/cm^2 for 195 seconds (165,750 $mW-s/cm^2$) was confirmed to have occurred. The measurements in this case were very difficult to accomplish because of the extremely short DF of the autotrack. Because the exposure was more than 46 times greater than the existing PEL it is somewhat difficult to understand why the subjective reactions were so mild. The ambient weather conditions at the time of the incident, e.g., temperature 53°F (11.7°C), humidity 47%, barometer 30.01 inches Hg (750.25 mm Hg), wind 7 knots, overcast with light rain, probably were significant contributors. The individual was extensively evaluated at the USAFSAM with special emphasis on reproductive function. The findings were all unremarkable and the individual is apparently entirely well today.

Example 3: In March of 1978 three U S. Army personnel were conducting a routine maintenance check on an MPQ-46 Hawk Illuminator, which was installed at an isolated U.S. Army site, but supported by a U.S. Air Force base nearby. No unusual circumstances were known to have precipitated the accident, other than simple carelessness on the part of the personnel involved.

The reconstruction/investigation was conducted by the USAFRHL at the request of the Base BEE charged with supporting the site. Since the Air Force had responsibility for site support, all elements of the Air Force RFR protection program applied. Of the three individuals involved, two were determined to have possibly been exposed to RFR levels of 90 mW/cm² for an indeterminate length of time, but certainly for longer than 6 minutes. Therefore, the existing PEL may have been exceeded. It was the opinion of the investigating officer that, in reality, the two were probably not overexposed at all because the evidence strongly suggested that the antenna was in motion during the entire time of alleged exposure. However, in the absence of reliable witnesses to that effect, it was elected to err on the side of conservatism and assume the worst case, e.g., the antenna was stopped and searchlighting the exposees.

The third individual was conclusively determined to have been exposed to 30 mW/cm² for 6 seconds (2100 mW-s/cm²), which was well below the existing PEL.

It was recommended to U.S. Army medical authorities that the two individuals who may have been exposed be evaluated by physicians who were familiar with RFR overexposures, etc.

Example 4: In October of 1978, an avionics technician was assisting with the checkout of an APQ-100 radar on an F-4C while parked on the flight line. The APQ-100 is a fire control radar operating in the low X-band with an average power of 110 watts. The technician was within approximately 1 foot (0.30 meters) of the antenna at the time of the incident.

The reconstruction/investigation was conducted by the Base BEE in consultation with the USAF OEHL. Because of the extremely high power densities encountered very close to such an emitter, it was impossible to accurately quantify the upper limit of the exposure, but a reasonable estimate based on experience and more distant measurements, was perhaps 400 mW/cm² for 240 seconds (96,000 mW-s/cm²). This exceeds the PEL by almost 27 times. The technician was acutely aware of a sensation of subjective heating. He also manifested a somewhat unusual skin rash over the upper trunk, head and neck for 2 to 3 days after the incident.

The technician was extensively evaluated at the USAFSAM and all observations were unremarkable. It was the USAFSAM physician's opinion that the skin rash was unrelated to the incident and it resolved without sequelae within 2 or 3 days. The tecnician is apparently entirely well today.

Example 5: In April of 1980 a USAF civilian avionics repair technician was conducting a final checkout of the avionics of an F-15A. He was not involved with the APG-63 radar, which was inadvertently energized while the technician was in front of the antenna. He promptly reported an intense sensation of heat to his head and neck and moved out of the beam.

The investigation/reconstruction was conducted by the USAF OEHL at the request of the Base BEE. There were a number of vagaries attendent to this incident and the investigation/reconstruction was quite complex. The ultimate determination, however, was that the technician was exposed to 550 mW/cm² for 15 seconds (8250 mW-s/cm²), which was more than twice the existing PEL.

The individual was extensively evaluated at the USAFSAM without significant findings and is apparently entirely well today.

Example 6: In September of 1983 eight civilian radar technicians were conducting antenna repairs and modifications on an FPS-92 tracking radar. Two of the technicians were U.S. Air Force civilians while the other six were employees of the USAF contractor responsible for the operation of the radar. The FPS-92, which operates in the mid-UHF region of the spectrum, was somehow energized while six of the eight individuals were working on the surface of the eighty-five foot (26 meters) diameter dish. At the time the average power output was between 100 and 150 Kilowatts.

The investigation/reconstruction was conducted by two RFR experienced BEEs who were stationed near the site, in close consultation with the USAF OEHL. These measurments revealed that two of the individuals were exposed to only a very small fraction of the PEL while the other six were exposed to power density levels ranging from 20 to 145 mW/cm^2 for eight minutes (480 seconds). These exposures are significantly in excess of the PEL.

All six of the exposees have undergone extensive medical evaluations at the USAFSAM and four have also been evaluated at one or more civilian institutions. The preliminary results obtained from the medical files at USAFSAM are inconclusive in that no findings were noted that could be directly attributed to the exposures, with the exception of acute situational anxiety reactions. All other manifestations were viewed as being transitory in nature with no permanent effects expected. Reevaluations of these individuals are expected to continue on a regular basis for some years to come.

In each of the examples noted, plus all of the other incidents investigated, the results are meticuously documented and copies of that documentation made a permanent part of the individual's medical record. In addition, a more detailed record is also reposed at the USAF OEHL.

V. SUMMARY OF MEDICAL EVALUATION RESULTS

Medical evaluations have been done on many, but not all of the personnel involved in RFR overexposures at Air Force bases since 1972. Not all of the personnel involved have been Air Force employees. There have been incidents on Air Force bases that involved civilian contractors, foreign nationals, U.S. Army and U.S. Marine Corps personnel.

In many cases the medical data obtained from the evaluations of the accidental RFR overexposures are incomplete in several respects, primarily due to a lack of standardization of the clinical examinations. Nevertheless, these case files can and do provide important anecdotal information concerning human exposure to RFR fields. This repository of case files is the only one of its kind known to exist.

Of the more than 330 (as of 1 Aug 84) suspected individual overexposure files in the repository, only 58 were positively confirmed to have exceeded the PEL. Of those 58, 26 individuals reported that they clearly felt a warming sensation at the time of the overexposure, 20 felt no warmth, and 12

were not sure. It can therefore be concluded that about 45% of those overexposed felt the energy and probably as a consequence of that feeling terminated the exposure. Of the approximately 240 alleged overexposures that were later positively confirmed as not exceeding the PEL, 26 felt a warming sensation and terminated the exposure before the PEL could be exceeded, 173 individuals felt no sensation and 39 were not sure.

Tables 2 through 7 summarize the accidental RFR exposures as a function of frequency, average power density, and exposure time.

Table 2

Confirmed Overexposures as a Function of Frequency

Number of Individuals	Frequency Range
1	20 MHz
7	200 - 500 MHz
18	1.5 - 6 GHz
24	8.0 - 10 GHz
5	15 - 35 GHz
3	Unknown

Table 3

Confirmed Overexposures as a Function of Average Power Density

Number of Individuals	Power Density Range (mW/cm^2)
9	15 - 30
16	40 - 100
14	120 - 250
13	350 - 1,000
3	1,000 - 3,000
1	16,000 - 100,000
1	100,000 - 160,000
1	Unknown

Table 4

Confirmed Overexposures as a Function of Exposure Time

Number of Individuals	Exposure Time Range
7	1 - 10 secs
11	15 - 60 secs
18	1 - 6 mins
21	8 - 60 mins
1	Unknown

Table 5

Accidental RFR Exposures Within the PEL* as a Function of Frequency

Number of Incidents	Frequency Range
2	1 - 10 MHz
3	20 - 90 MHz
14	0.1 - 0.9 GHz
61	1.0 - 6.0 GHz
30	8 - 10 GHz
3	10 - 14 GHz
20	15 - 35 GHz
66	Unknown

*PEL = 3600 mW-s/cm² in any 6 min period.

Table 6

Accidental RFR Exposures Within the PEL*
as a Function of Average Power Density

Number of Incidents	Power Density Range (mW/cm²)
95	0 - 1
57	1 - 14
20	15 - 39
23	40 - 100
1	101 - 250
1	251 - 1,000
2	Unknown

*PEL = 3600 mW-s/cm² in any 6 min period.

Table 7

Accidental RFR Exposures Within the PEL* as a Function of Exposure Time

Number of Incidents	Exposure Time Range
29	0 - 1 sec
39	1 - 11 sec
36	15 - 60 sec
29	1 - 6 min
45	8 - 60 min
14	2 - 100 hrs
3	101 - 500 hrs
4	Unknown

*PEL = 3600 mW-s/cm² in any 6 min period.

VI. CLINICAL IMPRESSIONS

Medical review of the results of the physical examinations that were conducted following RFR overexposures have revealed few, if any, consistent clinical patterns. Even in the cases where very intense localized exposures occurred, erythema and/or edema were rarely seen at the time of the physical examination. Lenticular imperfections such as small punctate opacities and vacuoles were noted frequently in individuals whose overexposure was primarily to the head. However, none of these observations were felt to have been clinically significant since no concomitant impairment to visual function could be noted. Also, and very significantly, it has not been possible to reliably determine whether any of these imperfections were present in the individuals prior to the RFR incident. These same types of ocular imperfections are very prevalent in the population at large and often encountered during routine ophthalmological examinations.

Detailed psychological testing has been accomplished on a number of the overexposees. The evaluators have, on occasion, attempted to draw some conclusions, but those efforts are severely hampered, if not prevented, by the absence of pre-radiation baseline data for comparison and interpretation. It is important to note also, that no abnormalities were noted during the neurological examinations that were conducted in concert with the psychological studies.

In the entire overexposed group, serum enzyme levels, blood counts, blood pressures, sedimentation rates, and electrocardiograms were all judged to be unremarkable after clinical review by several physicians well experienced in the evaluation of RFR exposees. This, of course, is very strong suggestive evidence that no clearly defined tissue damage had occurred.

Individuals accidently exposed to levels of RFR at or above the PEL often manifest clinical symptoms that usually include headache, nausea, fatigue, malaise, palpitations, etc. These symptoms can be attributed to an anxiety reaction to the exposure, but it is impossible to completely rule out an organic etiology. Some high level overexposures, e.g., >500 mW/cm^2, have resulted in anxiety reactions so severe that hospitalization and sedation were necessary. In some cases situational responses were severe enough to warrant psychiatric referral and evaluation.

Today, more sophisticated and formal review and analyses of these Air Force RFR accident medical files are underway. The general thrust of these analyses is toward evaluating the rate and type of clinical symptomology as a function of exposure level and frequency, and body part or area principally exposed.

VII. SOME PRELIMINARY CONCLUSIONS

As the present ongoing review and analysis of the accident files continues, additional information will be forthcoming and perhaps some more meaningful and important conclusions can then be drawn. In the meantime, however, the following somewhat crude conclusions are evident at this time:

1. Of the nearly 330 alleged overexposures investigated, less than 20% were confirmed, the remaining ~ 80% were within the PEL.

2. About half of the overexposures were detected by the exposee because of a subjective heating sensation.

3. Virtually all of the overexposures were of a partial body nature.

4. Most of the exposures occurred at frequencies between 1 and 10 GHz.

The United States Air Force's experience with alleged overexposure to RFR has been extensive and has been well documented. Exhaustive investigations have been conducted and sophisticated medical evaluations of the confirmed exposee have been accomplished. To this point in time there is no hard or soft evidence to suggest that any permanent damage or injury has taken place in the individuals involved.

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